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MINUTEMAN STAGE I MOTOR RELIABILITY IMPROVEMENT PROGRAM SURVEILLANCE

PROPELLANT LABORATORY SECTION

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MMEMP PROJECT M72632-5MP116P

MINUTEMAN STAGE I
MOTOR RELIABILITY
IMPROVEMENT PROGRAM
SURVEILLANCE

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ABSTRACT

This report contains data and test results from the third time testing of the Minuteman Stage I Reliability Improvement Program (RIP) Surveillance. Thiokol (see TWR-7300) had tested and reported on this program for eight years up through 30 June 1973. The responsibility was then turned over to the Propellant Laboratory (MANCP) at OO-ALC.

In the previous report, data was compared with Thiokol data and was presented in the same format as in Thiokol's final report. In this report, Thiokol's data with the data from three years of testing in MANCP's laboratory were combined and regression analysis was made by MANCP's statistical group.

The purpose of testing is to provide early warning if any serious degradation trends occur in the components being evaluated.

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INTRODUCTION

A. PURPOSE:

Quality assurance testing was conducted by Thiokol for eight years on the RIP program to evaluate the effects of aging on components. Since July of 1973, testing has been performed by the Propellant Laboratory (MANCP) at OO-ALC.

Evaluation of the test data should provide early warning if serious degradation trends occur. Annual evaluation of the components provide data that can be put into engineering reliability and service life predictions. Testing was performed in accordance with MMEMP Project M72632-5MP116P.

B. BACKGROUND:

The Minuteman Stage 1 Reliability Improvement Program (RIP) Surveillance program was conducted from its inception through 30 June 1973 by Thiokol/Wasatch Division under SAMSO direction (TWR-7300, 15 Nov 1974). On 1 July 1973, responsibility for testing was turned over to Ogden Air Logistics Center, Hill Air Force Base, Utah.

1. The primary program objectives were:

a. Demonstrate that the various components and subsystems meet the service life requirements specified by the motor model specifications.

b. Evaluate the storage behavior of components and subsystems so that the start of ageout in the operational force can be predicted or demonstrated in time to take corrective action.

c. Identify and verify failure modes in sufficient time to allow orderly replacement or rework of the missile force.

In addition, major program tasks were to evaluate the storage behavior of the RIP Stage I Minuteman motors under environmental conditions representative of the operational concept, and ultimately to aid in predicting the usable life of the operationally deployed motors.

2. Major tasks were:

a. Subject full scale motors to various simulated operational storage conditions and conduct tests and inspections to determine possible degradation due to storage.

b. Conduct thorough laboratory accelerated aging programs to support the full scale motor program.

c. Provide planning necessary for integrating operational and development motor surveillance programs as data becomes available from operational agencies.

d. Correlate and evaluate all data to establish criteria for determining modes of possible degradation due to aging.

e. Suggest means for reducing or preventing such degradation.

f. Evaluate the effects of aging on motor performance.

g. Provide meaningful estimates of the service life of stage one motors.

3. Component and laboratory specimens were stored at simulated in-situ conditions and elevated temperatures to induce accelerated

aging. Laboratory specimens were selected to evaluate the performance of suspected significant characteristics of the materials under study.

The objectives of the component and laboratory aging effort are:

a. Evaluate the aging characteristics of components materials and interfaces affecting the performance of a complete motor.

b. Evaluate the effects of interaction (by migration of materials that interface in the motor assembly).

c. Correlate accelerated aging results with ambient aging results to allow extrapolation of aging trends when insufficient ambient aging data are available.

d. Provide aging data to predict motor and component storage life.

e. Evaluate test specimens and test techniques for improvement of overall surveillance quality.

Component and laboratory specimens prepared by Thiokol were tested by this laboratory. The results are shown in the figures and are included with the results from TWR-7300 report. The testing at this time does not cover the full range of component testing reported in TWR-7300.

STATISTICAL ANALYSIS

In order to evaluate aging trends, the regression model $Y = a + bX$ was employed to evaluate latest test results with respect to past data. Each regression was plotted to display individual test points with a least squares trend line through them. A tolerance band is given to indicate that at ninety percent confidence ninety percent of any data sampling can be expected to be within this interval. A dashed three sigma (three standard deviation) band parallels the least squares trend line. These bands are extrapolated twenty-four months beyond the age of the test materials at the time they were last tested. Regression data at ages eight years and upward represent MANCP laboratory testing while previous data were generated by Thiokol.

To obtain an overall view of which materials and test parameters have significant aging trends , a table of significance of regression slopes is given, see Table 1. Statements of significance are given at the five percent level. For those regression parameters having established failure criteria, a one-sided regression analysis was used.

TEST RESULTS

A. TENSILE ADHESION:

Tenshear (RS-1) tensile adhesion specimens show a statistically significant increase for both the 0° and 45° angle tensile testing (Figures 1 and 2). The failure mode for the 0° testing was about 40% cohesive in the propellant and 60% adhesive propellant to liner; and for the 45° testing about 48% cohesive in the propellant and 52% adhesive propellant to liner.

Regression analyses for RS-3 (Figure 3), RS-4 (Figure 4), RS-20 (Figure 5) and RS-24 (Figure 6) show no significant aging trends.

The failure mode for RS-3 and RS-4 was determined by examination of the surface area with the aid of a microscope. For RS-3, the failure mode appears to be about 90% adhesive to primer and 10% primer to fiber on four specimens while the fifth specimen showed about 85% adhesive to primer, 10% primer to fiber and 5% cohesive in UF 31-43. For RS-4, the failure mode was about 70% cohesive in adhesive, 25% adhesive to fiber and 5% fiber failure. The RS-20 failure mode was 100% metal to adhesive. For RS-24, low adhesion silicone rubber to inlet graphite, the failure mode was about 90% adhesive carbon to rubber and 10% cohesive in the rubber for three specimens, 99% adhesive carbon to rubber and 1% cohesive in the rubber for one specimen, and the remaining specimen showed about 25% adhesive failure carbon to rubber and 75% cohesive in the rubber.

B. TENSILE STRENGTH:

The tensile strength for RS-5, RS-19A and RS-21 do not show significant trends (Figures 7 thru 10).

C. ELONGATION:

RS-5 and RS-19A show no change (Figures 11 and 19A). RS-12 shows a statistically significant gradual decrease (Figure 13) and RS-21 shows a statistically significant gradual increase (Figure 14).

CONCLUSIONS

The regressions show little or no change in trends from those previously established and are in good agreement with TWR-7300 data. Therefore, the service life of these components may be extended for at least two years beyond the last data point.

RECOMMENDATIONS

To assure the extended capability of these component materials, it is recommended that testing be continued.

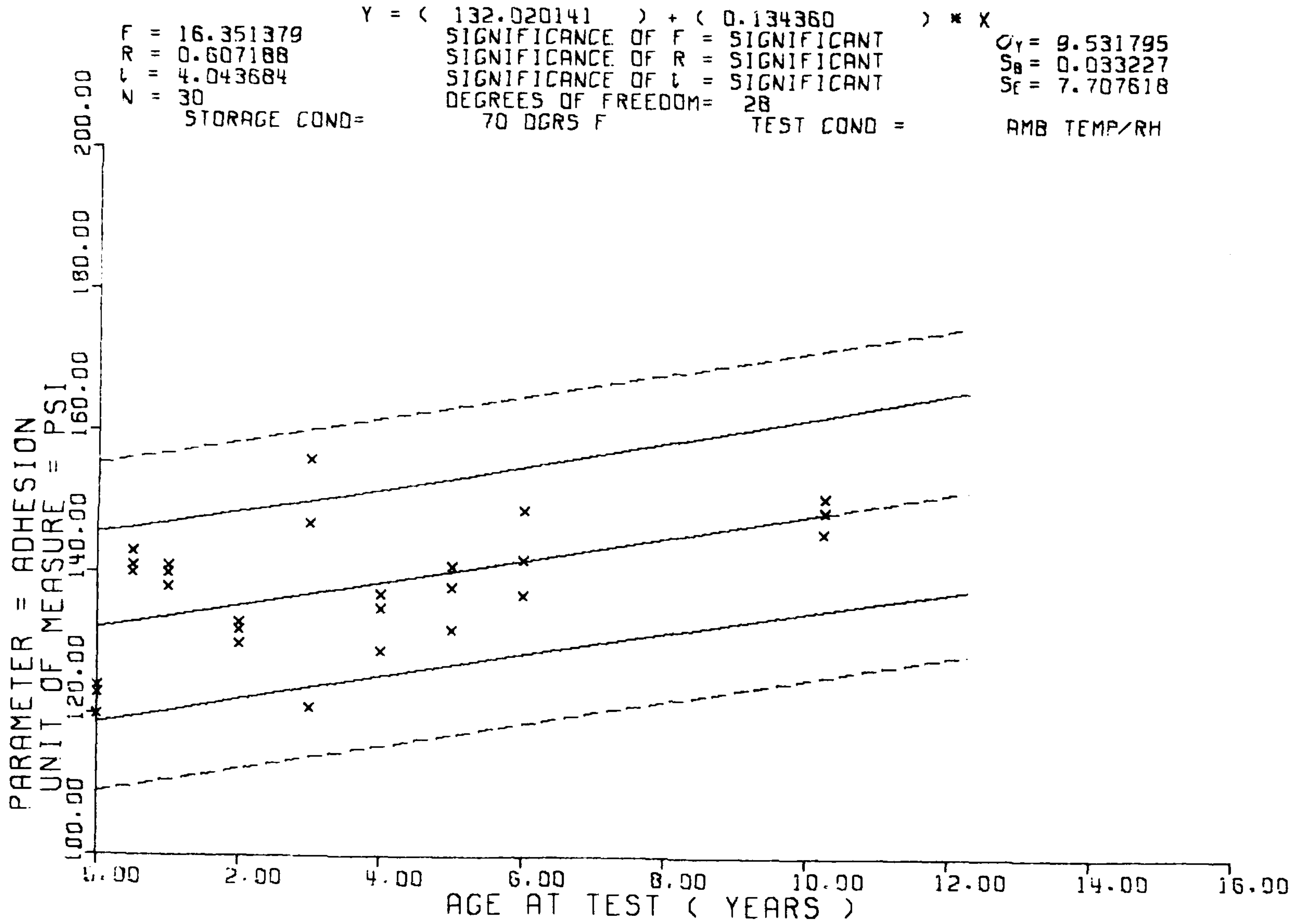
TABLE 1

Significance of Regression Slopes

		Slope	Significance of Slope	t-value	DF
RS-1	Adhesion at 0 deg	+	S*	4.04	28
RS-1	Adhesion at 45 deg	+	S*	3.28	28
RS-3	Tensile adhesion (Sm)	-	NS*	0.15	49
RS-4	Tensile adhesion (Sm)	+	S*	1.84	52
RS-20	Tensile adhesion (Sm)	-	NS*	0.98	51
RS-21	Tensile strength (Sm)	+	NS	1.24	99
RS-24	Tensile adhesion (Sm)	+	NS	0.09	46
RS-5	Tensile strength (Sm)	+	NS	0.38	77
RS-12	Tensile strength (Sm)	-	NS	1.53	100
RS-5	Elongation (er)	+	NS*	0.90	75
RS-12	Elongation (er)	-	S	3.11	83
RS-19A	Elongation (er)	+	NS	0.64	68
RS-21	Elongation (er)	+	S	2.06	83
RS-19A	Tensile strength (Sm)	-	S*	1.93*	57

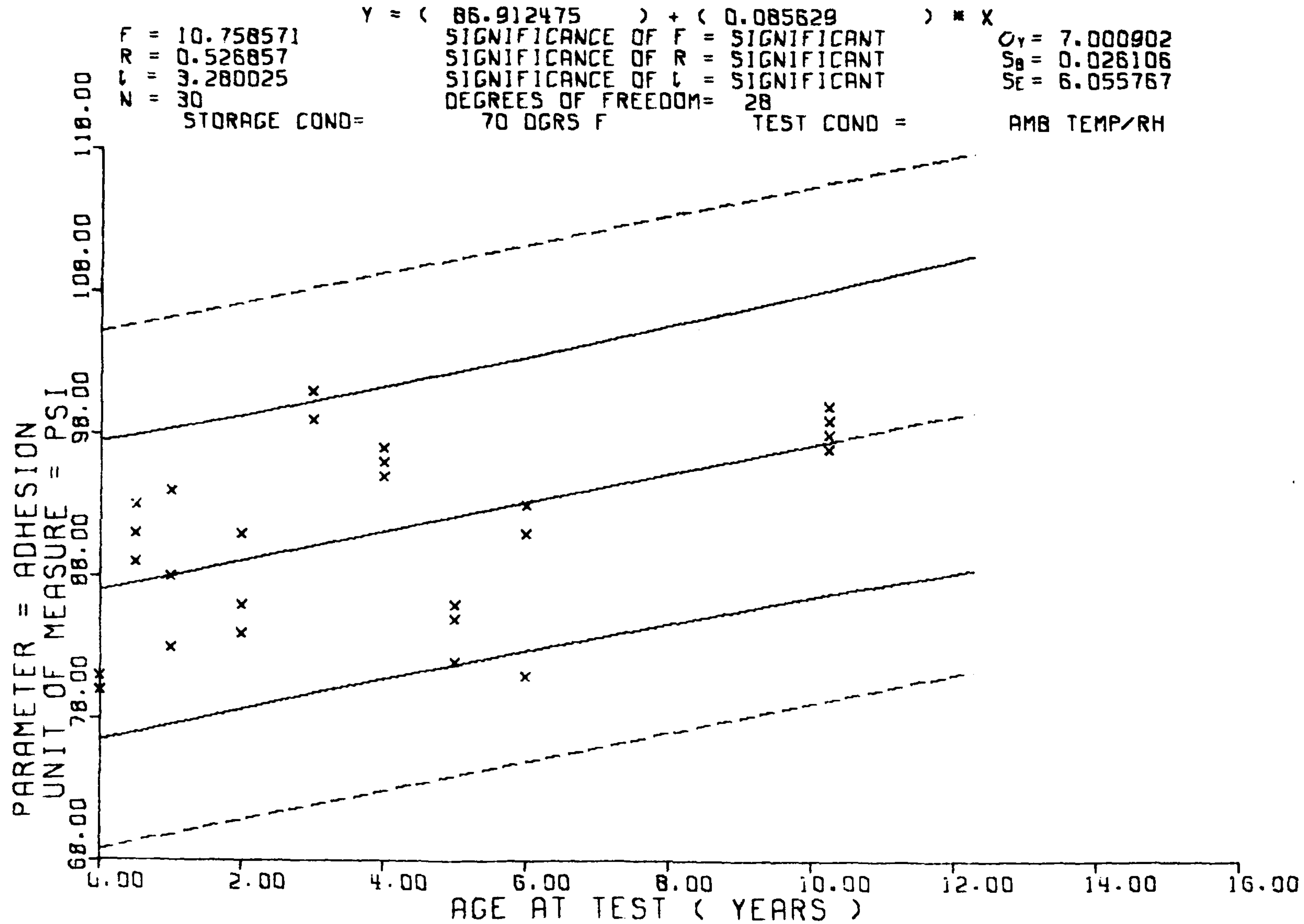
* Single sided regression analysis employed when a failure criteria is used.

DF = Degress of freedom
S = Significant
NS = Not significant



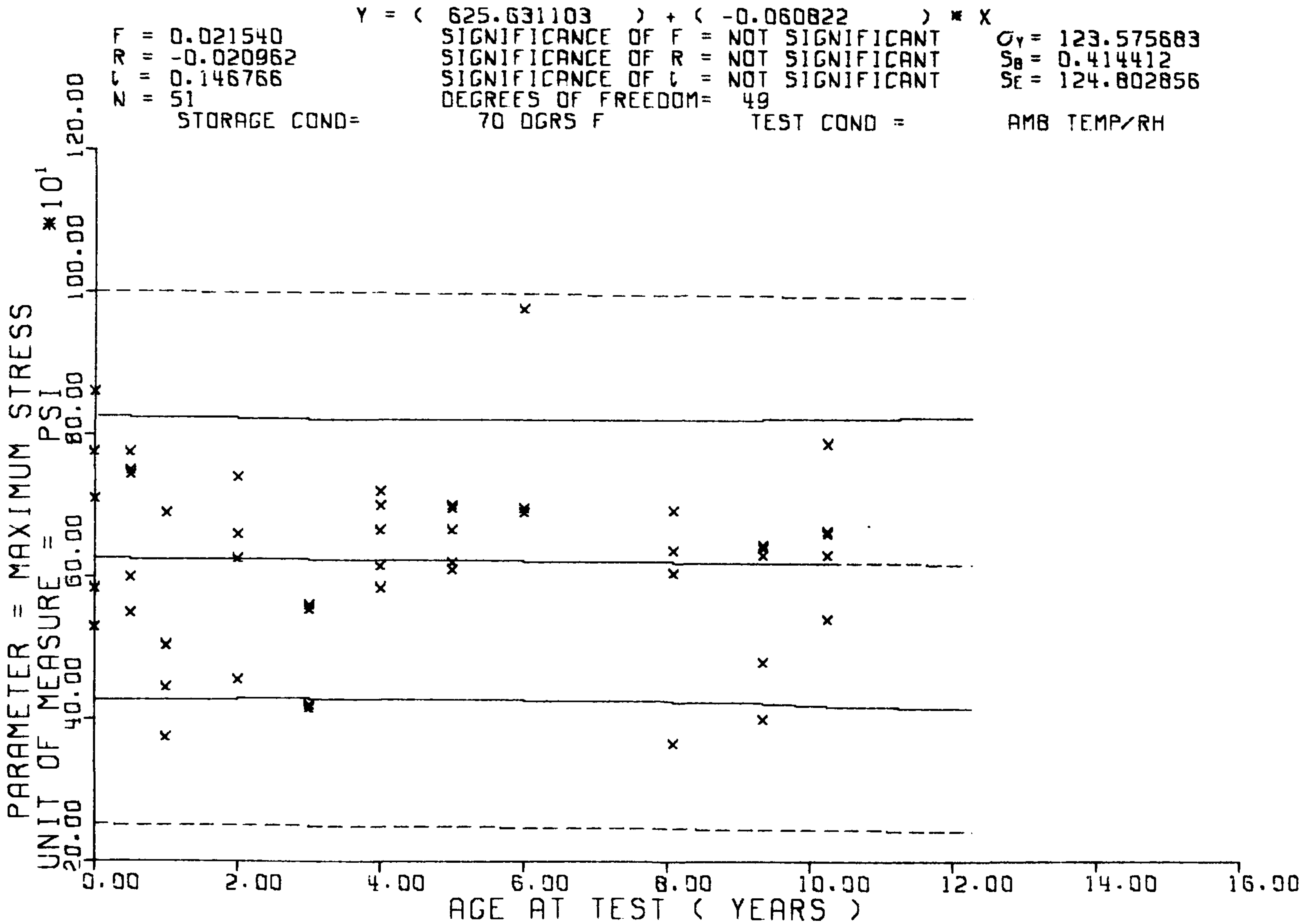
RS-1 (TENSHEAR) ADHESION AT 0 DEG ANGLE. FAILURE CRITERION: 10 PSI

Figure 1



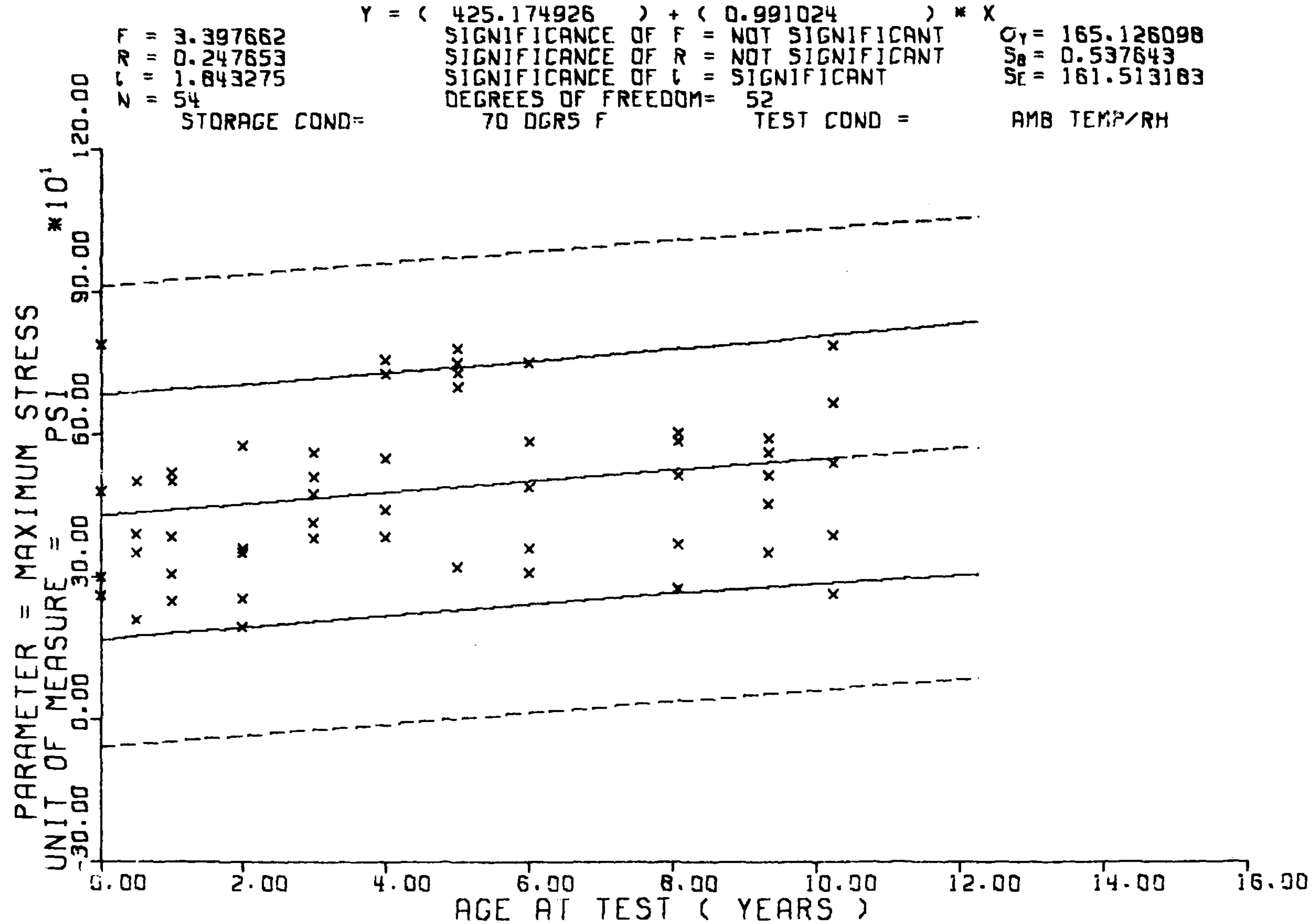
RS-1 (TENSHEAR) ADHESION AT 45 DEG ANGLE. FAILURE CRITERION: 10 PSI

Figure 2



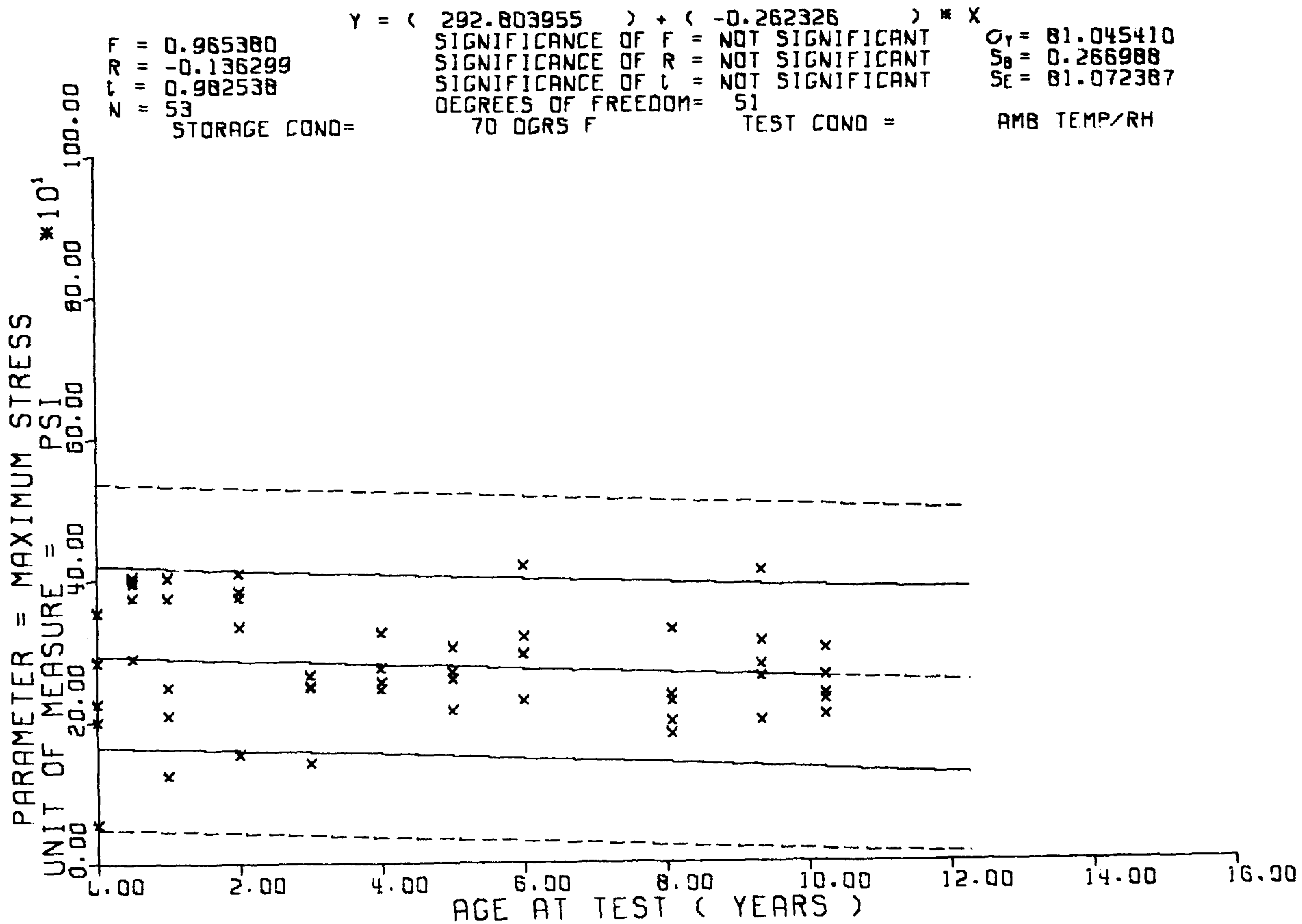
RS-3 TENSILE ADHESION (SM), FAILURE CRITERION: 10 PSI

Figure 3



RS-4 TENSILE ADHESION (SM), FAILURE CRITERION: 25 PSI

Figure 4



RS-20 TENSILE ADHESION (SM), FAILURE CRITERION: 10 PSI

Figure 5

Y = (283.830322) + (0.038043) * X

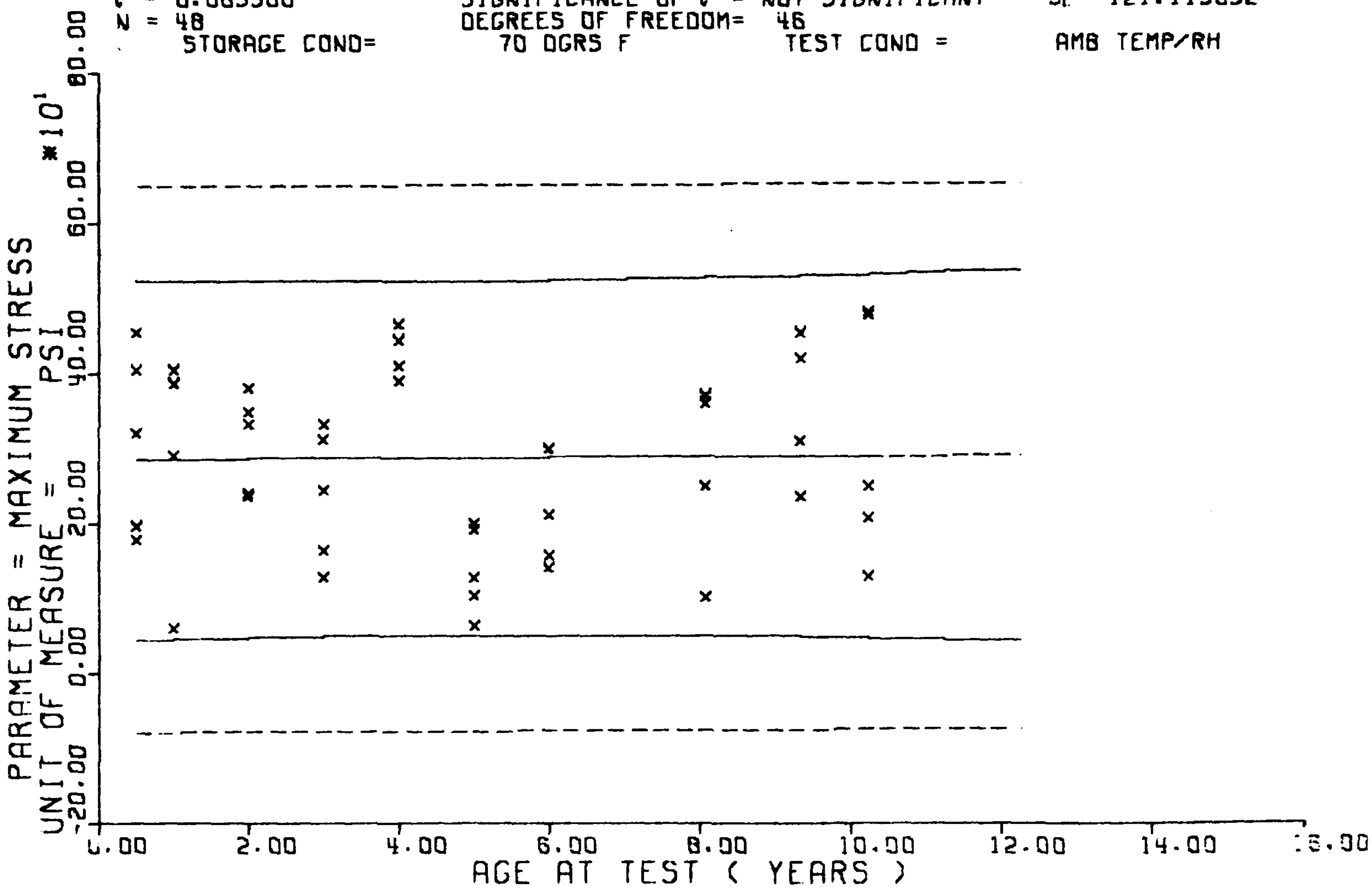
F = 0.007310 SIGNIFICANCE OF F = NOT SIGNIFICANT σ_Y = 119.829833

R = 0.012605 SIGNIFICANCE OF R = NOT SIGNIFICANT S_B = 0.444950

t = 0.085500 SIGNIFICANCE OF t = NOT SIGNIFICANT S_E = 121.115692

N = 48 DEGREES OF FREEDOM= 46

STORAGE COND= 70 DGRS F TEST COND = AMB TEMP/RH



RS-24 TENSILE ADHESION (SM)

Figure 6

Y = (1726.006835) + (0.259739) * X

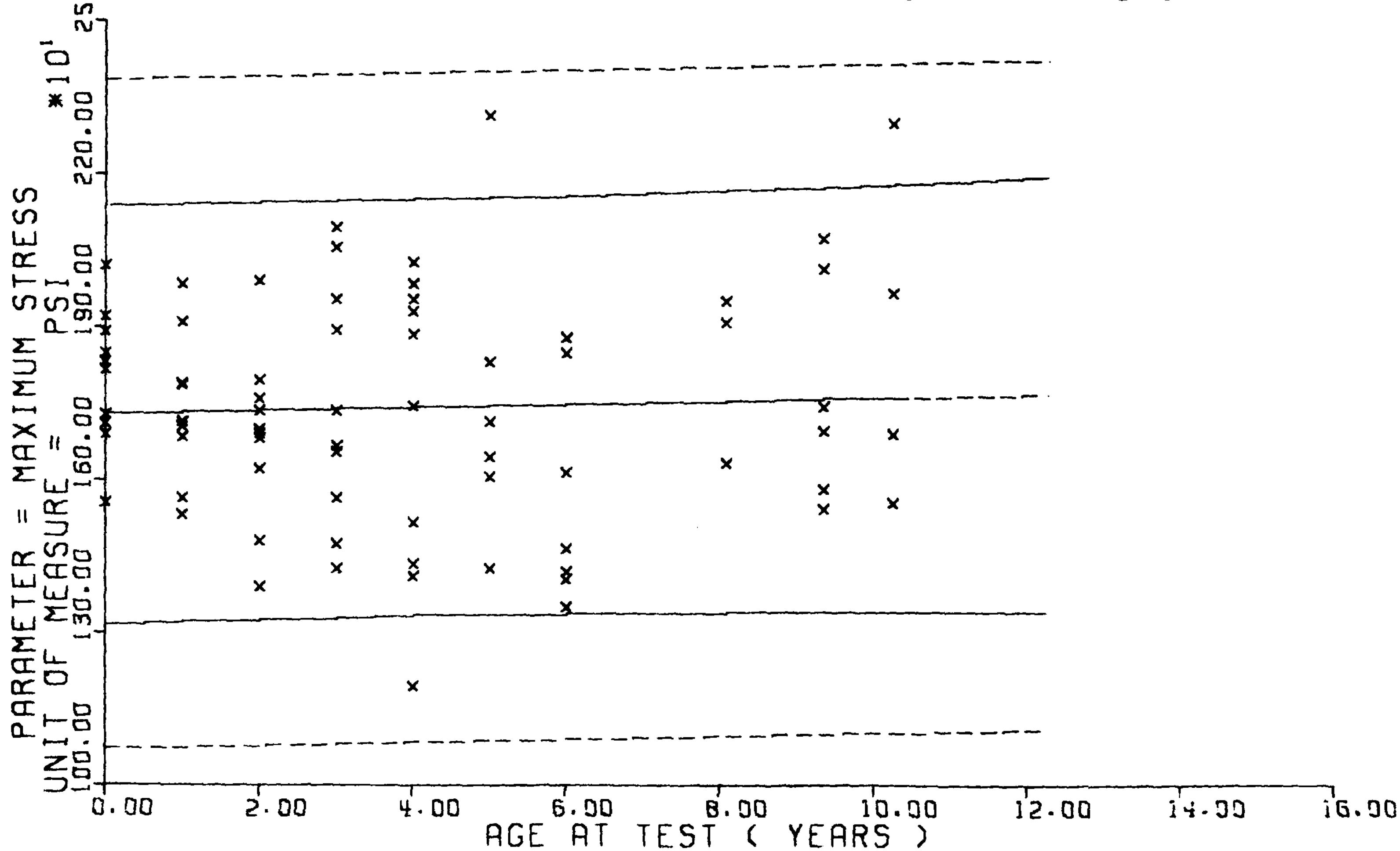
F = 0.144749 SIGNIFICANCE OF F = NOT SIGNIFICANT σ_Y = 217.470581

R = 0.043317 SIGNIFICANCE OF R = NOT SIGNIFICANT S_B = 0.682701

t = 0.380459 SIGNIFICANCE OF t = NOT SIGNIFICANT S_E = 218.672729

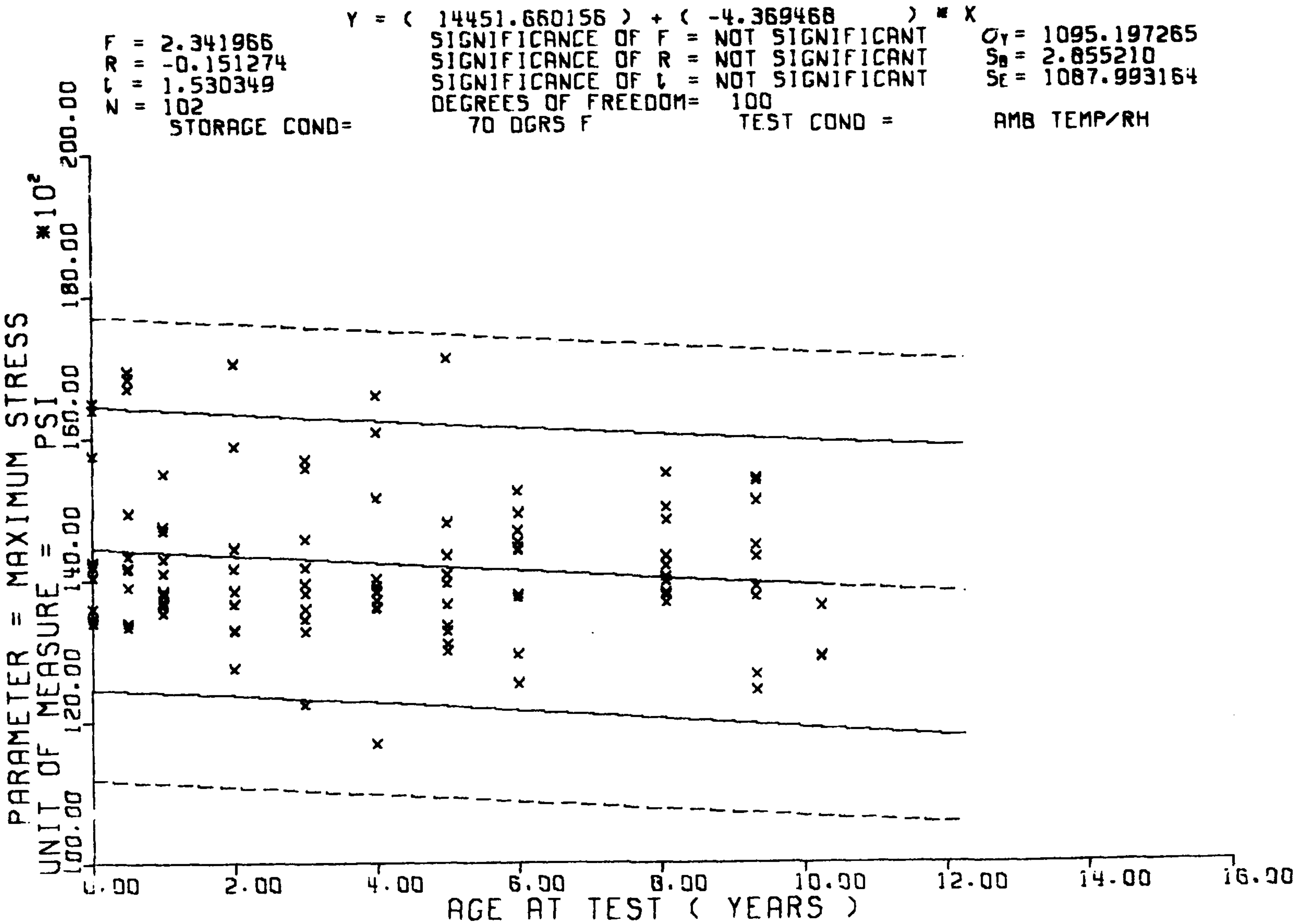
N = 79 DEGREES OF FREEDOM= 77

STORAGE COND= 70 DGRS F TEST COND = AMB TEMP/RH



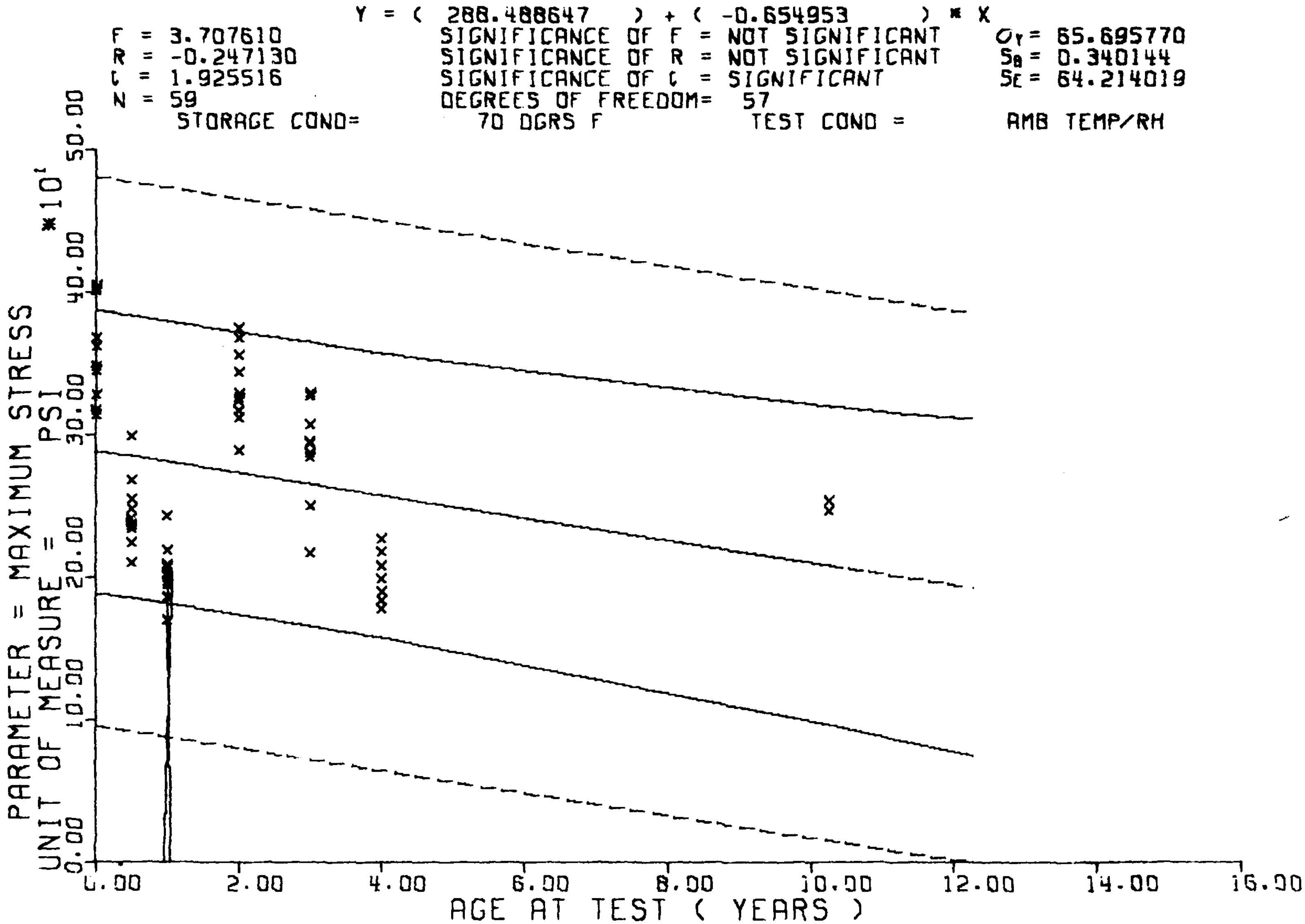
RS-5 TENSILE STRENGTH (SM)

Figure 7



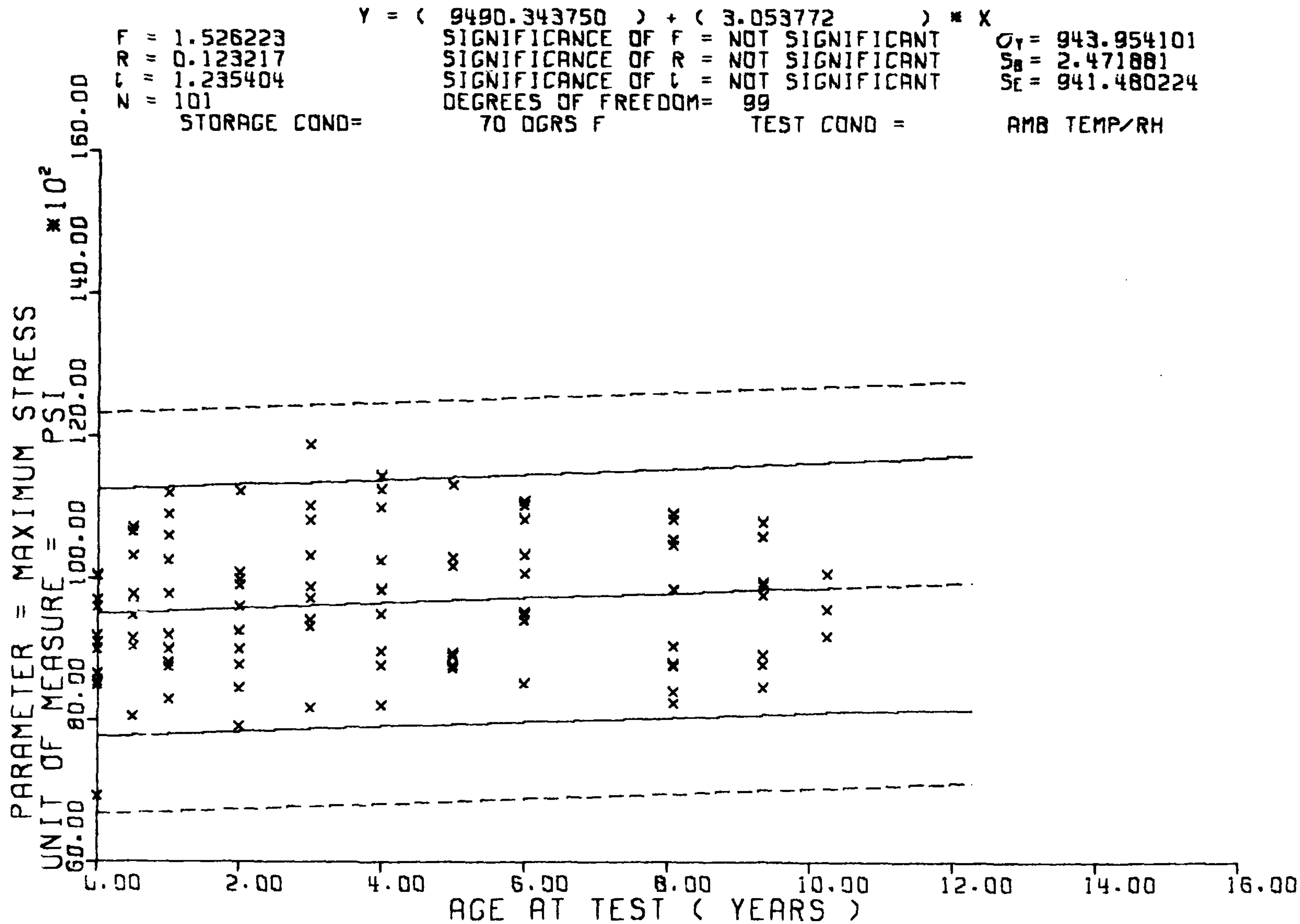
RS-12 TENSILE STRENGTH

Figure 8



RS-10A TENSILE STRENGTH (SM). FAILURE CRITERION: 10 PSI

Figure 9



RS-21 TENSILE STRENGTH (SM)

Figure 10

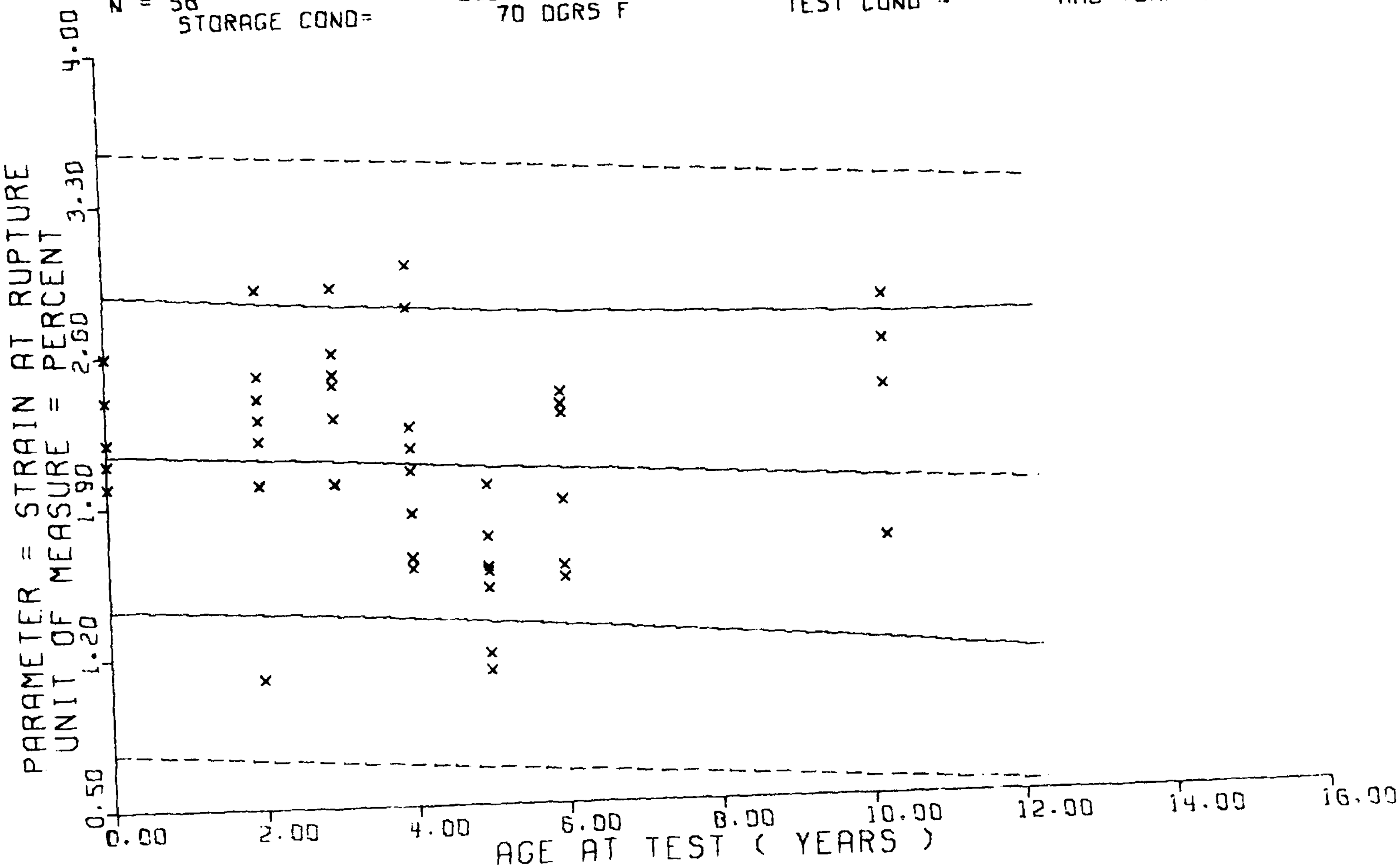
Y = (2.153505) + (-0.001498) * X

F = 0.583859
R = -0.101580
t = 0.764107
N = 58

SIGNIFICANCE OF F = NOT SIGNIFICANT
SIGNIFICANCE OF R = NOT SIGNIFICANT
SIGNIFICANCE OF t = NOT SIGNIFICANT
DEGREES OF FREEDOM= 56

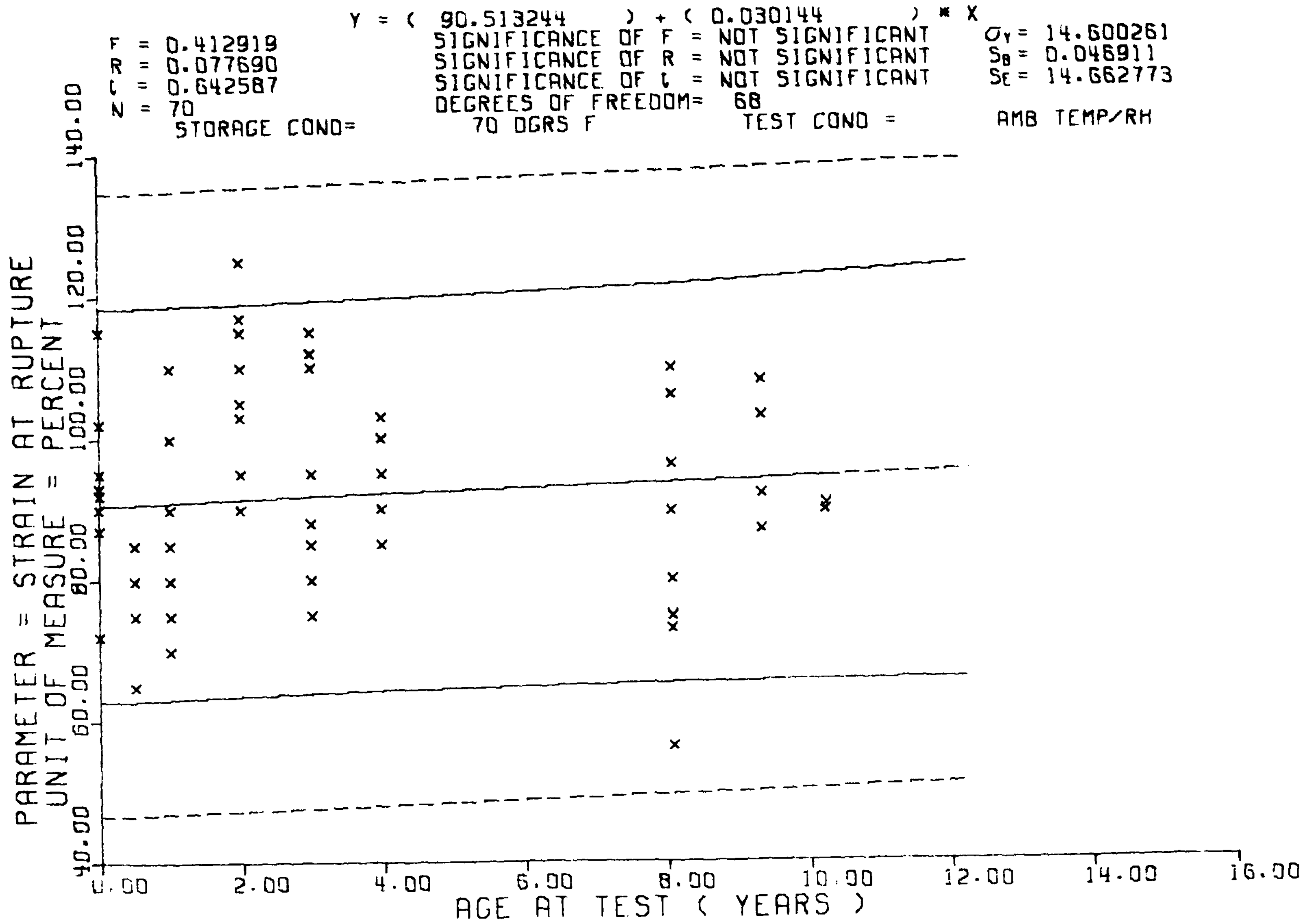
σ_Y = 0.462408
S_B = 0.001960
S_E = 0.464105

STORAGE COND= 70 DGRS F
TEST COND = AMB TEMP/RH



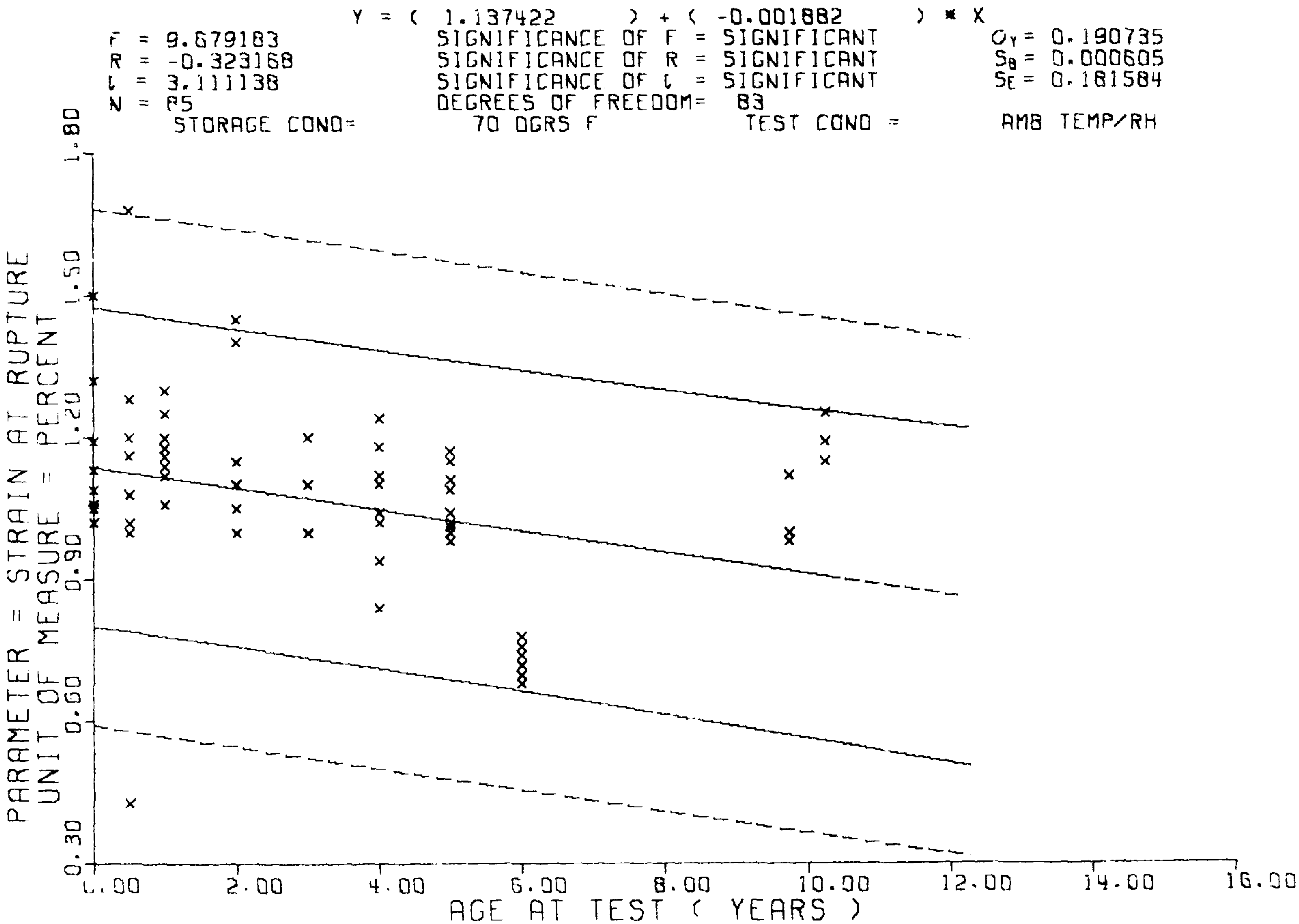
RS-5 ELONGATION (ER). FAILURE CRITERION: 0.36 PERCENT STRAIN

Figure 11



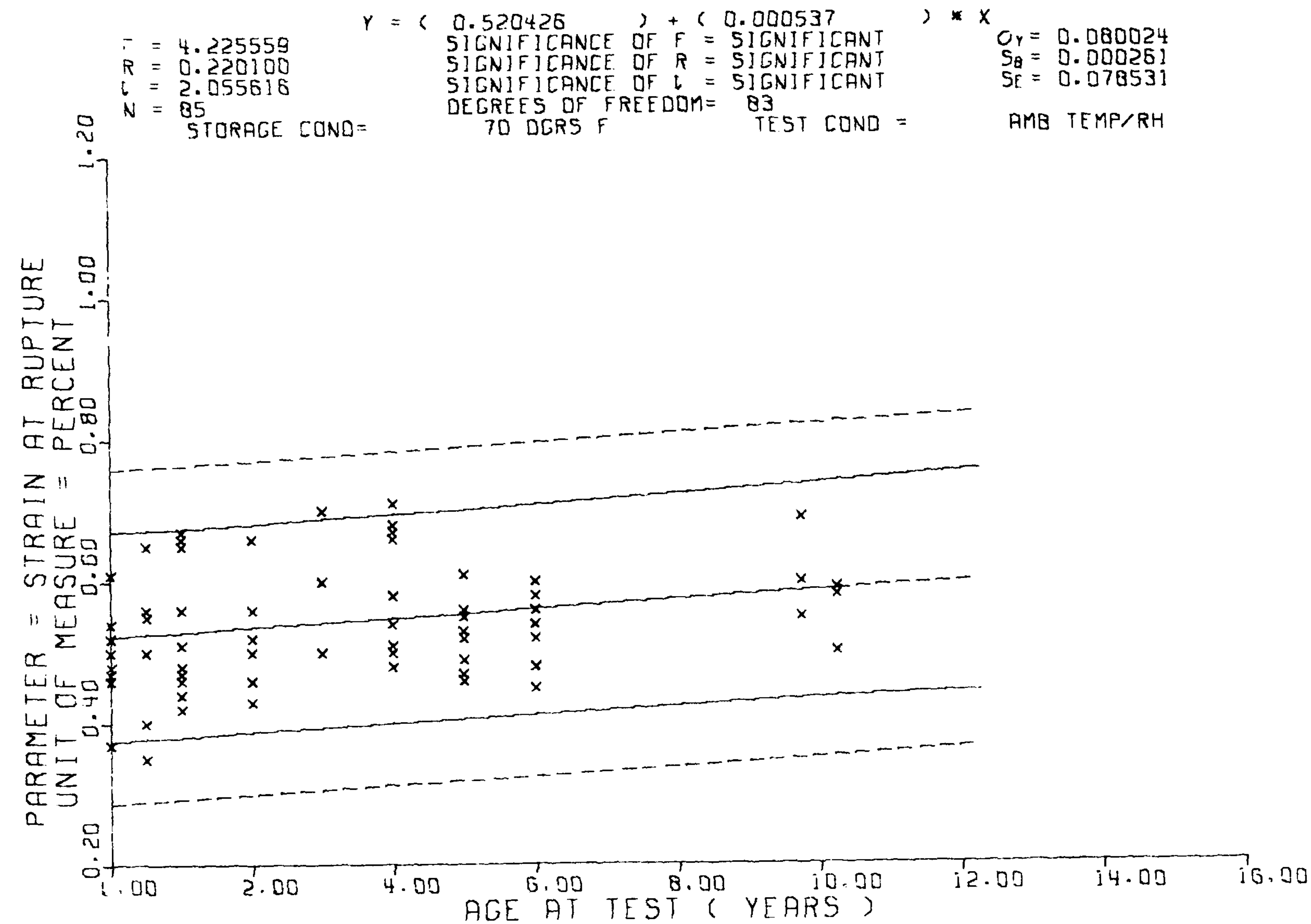
RS-19A ELONGATION (ER)

Figure 12



RS-12 ELONGATION (ER)

Figure 13



RS-21 ELONGATION (ER)

Figure 14

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This report contains data and test results from the third time testing of the Minuteman Stage I Reliability Improvement Program (RIP) Surveillance. Thiokol (See TWR-7300) had tested and reported on this program for eight years up through 30 June 1973. The responsibility was then turned over to the Propellant Laboratory (MANCPO at OO-ALC.

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